Global Navigation Satellite Systems (GNSS)

NovAtel's complete line of precise positioning engines, enclosures, antennas and software is developed to meet a wide range of accuracy and cost requirements for all satellite navigational systems.

Precise thinking

GALILEO

The emerging Galileo system, sponsored by the European Union and managed by the European Space Agency (ESA), launched the GIOVE-A test satellite on December 28, 2005. Full operational deployment of the constellation is expected by 2012. A ground-based control system will also be developed and deployed, similar to the GPS Control Segment. In addition to controlling the satellites, the Galileo Ground Mission Segment will also generate integrity information for Safety of Life users similar to the US FAA Wide Area Augmentation System.

30 satellites will be organized into three orbital planes consisting of 9 satellites and one spare with an inclination of 56 degrees, making a complete orbit in approximately 14 hours, 21 minutes. Satellites will broadcast using spread-spectrum modulation on E1, E5A, E5B and E6 frequencies.

Consult www.esa.int/esaNA/galileo.html for exact development status of the Galileo constellation and its capabilities. On July 26, 2007, an agreement was announced between the European Union and the United States to create interoperable E1/L1 signals. The information shown here reflects all public information with respect to those common signals.

Fundamental frequency (Fo)	10.23 MHz

RF Carrier

E1 frequency (Galileo)	1575.42 MHz
E5A frequency (Galileo) (115 * Fo)	1176.45 MHz
ALT BOC signal covers the bandwidth of both E5A and E5B (116.5 * Fo)	1191.795 MHz (centre frequency)
E5B frequency (Galileo) (118 * Fo)	1207.14 MHz
E6 frequency (Galileo) (125 * Fo)	1278.75 MHz

Code chip

E1 code chip (Galileo A channel) (Fo / 4) Frequency	616 L1 cycles / chip 2.5575 MHz
E1 code chip (Galileo B&C channel) (Fo / 10) Frequency	1540 cycles / chip 1.023 MHz
E5A code chip (Galileo) (Fo)	115 E5a cycles / chip 10.23 MHz
E5B code chip (Galileo) (Fo) Frequency	118 E5b cycles / chip 10.23 MHz
E6A	Not published
E6 B/C code chip (Galileo) (Fo) Frequency	250 E6 cycles / chip 5.115 MHz
Alt-BOC code chip (Galileo) (Fo) Frequency	N/A cycles / chip 10.23 MHz

Pseudorandom noise (PRN) sequence

E1A channel (PRS) Subscript cos implies a cosine-shaped subcarrier, otherwise a sine-shaped subcarrier relationship is implied	$BOC_{cos}(15, 2.5)$	Not published
E1B channel pseudorandom noise sequence Length Primary code period Secondary code length	CBOC(6,1,1/11)	 4092 E1B code chips 4 msec N/A
E1C channel pseudorandom noise sequence Length Primary code period Secondary code length	CBOC(6,1,1/11)	 4092 E1C code chips 4 msec 25 chips
E5A I channel pseudorandom noise sequence Primary code length Primary code period Secondary code length	BPSK(10)	 10230 E5A code chips 1 msec 20 chips
E5A Q channel pseudorandom noise sequence Primary code length Primary code period Secondary code length	BPSK(10)	 10230 E5A code chips 1 msec 100 chips
E5B I channel pseudorandom noise sequence Primary code length Primary code period Secondary code length	BPSK(10)	 10230 E5B code chips 1 msec 4 chips
E5B Q channel pseudorandom noise sequence Primary code length Primary code period Secondary code length	BPSK(10)	 10230 E5B code chips 1 msec 100 chips
E6A channel pseudorandom noise sequence	$BOC_{cos}(10,5)$	Not published - PRS
E6B channel pseudorandom noise sequence Secondary code length	BPSK(5)	5115 E6B code chips 1 msec 100 chips
E6C channel pseudorandom noise sequence Secondary code length	BPSK(5)	5115 E6B code chips 1 msec 100 chips

Nav bit

Open Service data	(E5A-I channel)	50 symbols / second
Safety of Life Service data	(E1B and E5B-I channels)	250 symbols/second
Commercial Service data	(E6B channel)	1000 symbols/second

GPS

Declared fully operational in 1995, the Global Positioning System (GPS) constellation in 2007 consists of 30 satellites in Full Operation Capability (FOC) status. The satellites are organized into six orbital planes with an inclination of 55 degrees, making a complete orbit in approximately 11 hours, 58 minutes.

All satellites are dual-frequency and broadcast on L1 and L2 using spread-spectrum modulation. L5 is currently broadcast from a WAAS geostationary satellite. As of November 2007, four satellites are broadcasting L2C. The GPS Modernization program will deploy L2C and L5 capability on a new generation of Block IIF, Block IIR-M and Block III satellites, as well as deploying the new M-code signals on L1 and L2 for exclusive US military use.

Consult www.navcen.uscg.gov/gps for exact operational status of the GPS constellation and its capabilities.

Fundamental frequency (Fo)	10.23 MHz

RF Carrier

L1 Frequency (GPS) (154 * Fo)	1575.42 MHz
L2 frequency (GPS) (120 * Fo)	1227.6 MHz
L1C frequency (154 * Fo)	1575.42 MHz
L2C frequency (120 * Fo)	1227.6 MHz
L5 frequency (115 * Fo)	1176.45 MHz

Code chip

L1 C/A code chip (Fo / 10 = 1.023 MHz)	1540 L1 cycles / chip
L1C code chip (Fo / 10 = 1.023 MHz)	1540 L1 cycles / chip
L1 P-code chip (Fo = 10.23 MHz)	154 L1 cycles / chip
L2 P-code chip (Fo = 10.23 MHz)	120 L2 cycles / chip
L2C code chip; L2-CM = civil-moderate; L2-CL = civil long Time multiplexed; resulting in apparent chipping rate of 511.5 kbps	(L2-CM) first half of period of 1.955 usec (L2-CL) second half of period of 1.955 usec
L5 code chip (Fo = 10.23 MHz)	115 L5 cycles / chip

Pseudorandom noise (PRN) sequence

L1 C/A code pseudorandom noise sequence	Length = 1023 C/A chips Period = 1 msec
L1P-code pseudorandom noise sequence sequence	Length = 6.187 X 10^{12} chips Period = 1 week
L1C pseudorandom noise sequence for data (L1Cd) BOC(1,1)	Length = 10,230 code chips Period = 10 msec
L1C pseudorandom noise sequence for pilot (L1Cp) = TMBOC All symbols are BOC(1,1) except those BOC(6,1) symbols that occur in the i_{th} location of 10230 chip sequence (i=0,4,6,29,33,37,39,62….101897,10201,10203,10226)	Length = 10,230 code chips Period = 10 msec
L2 P-code pseudorandom noise sequence	Length = 6.187 X 10^{12} chips Period = 1 week
L2-CM pseudorandom noise sequence	Length = 10,230 chips Period = 20 msec
L2-CL pseudorandom noise sequence	Length = 767,250 chips Period = 1500 msec
L5 pseudorandom noise sequences for data (L5-I) BPSK(10)	Length = 10,230 chips Period = 1 msec
L5 pseudorandom noise sequences for pilot (L5-Q) BPSK(10)	Length = 10,230 chips Period = 1 msec

Nav bit

GPS L1 Navigation bit	Bit length=20 PRN sequences of L1 50 bits / sec
GPS L1P navigation bit	Unpublished
GPS L1C (data)	Symbol length=1 PRN sequence of L1C 100 symbols / sec
GPS L1C (pilot)	Pilot: Secondary overlay code sequence of 1800 bits, 18 second period is modulo-2 added to the pilot
GPS L2-CM navigation bit	Symbol length=1 PRN sequence of L2C = 1.955 usec 100 symbols / sec after half-rate coding of 50 symbols / sec
GPS L2P Navigation bit	Unpublished
GPS L5 navigation bit (L5-I) L5-I signal: secondary code of 10 bits (1 L5 PRN sequence / bit) L5-Q signal: secondary code of 20 bits (1 L5 PRN sequence / bit)	The symbols of the data code are aligned to the symbols of the secondary code and have the same period per symbol as the complete secondary code of the data signal (10 ms or 100 symbols / sec)

GLONASS

The Global Navigation Satellite System (GLONASS) constellation is operated for the Russian government by the Russian Space Forces. The constellation had dwindled to 7 operational satellites in 2001. As of mid-2007, there are now 14 satellites declared operational, with plans announced to increase this total to 18 by the end of 2007.

These satellites are organized into three orbital planes with an inclination of 64.8 degrees, making a complete orbit in approximately 11 hours, 15 minutes. Each satellite broadcasts L1 and L2 signals on unique frequency channels (see below). Plans have been announced for an L3 signal at 1201.5 MHz. A decision will be made at the end of 2007 whether this signal will be modulated with CDMA (similar to GPS) or FDMA (similar to GLONASS L1 and L2).

Consult www.glonass-ianc-rsa.ru for exact operational status of the GLONASS constellation and its capabilities.

Fundamental frequency (Fo)	10.23 MHz

RF Carrier

L1 frequency (GLONASS) for $F_{k=0}$, K = (-7 to +13) Channel spacing = 562.5 kHz	1602.000 MHz (k = 0)
L2 frequency (GLONASS) for $F_{k=0}$, K = (-7 to +13) Channel spacing = 437.5 kHz	1246.000 MHz (k = 0)

C/A code chip

L1 standard accuracy code chip (GLONASS) Frequency	3135.03 cycles / chip 0.511 MHz
L1 high accuracy code chip (GLONASS) Frequency This number only applies for the center frequency and will change depending on the GLONASS satellite being tracked	313.503 cycles / chip 5.11 MHz
L2 standard accuracy code chip (GLONASS) Frequency	2438.36 L2 cycles / chip 0.511 MHz
L2 high accuracy code chip (GLONASS) Frequency	243.836 L2 cycles / chip 5.11 MHz

C/A pseudorandom noise sequence

GLONASS L1 standard accuracy pseudorandom noise sequence	Length = 511 code chips Period = 1 msec
GLONASS L2 standard accuracy pseudorandom noise sequence	Length = 511 code chips Period = 1 msec

Nav bit

GLONASS Navigation Bit 1 bit length (1 data bit is made up of two meander bits)	20 PRN sequences per data bit 100bps(meander)/50bps(data)
GLONASS Navigation String (applicable for L1 and L2 on M-class satellites only)	String length 85 data bits @ 50 bps +30 bits time mark @ 100 bps String data rate 0.5 Hz per string

COMPASS

COMPASS is a GNSS system announced by the People's Republic of China that is currently in the development stage. ITU filings for radio navigation frequency allocation indicate that the system will transmit on 1589.74 MHz, 1561.1 MHz, 1268.52 MHz, 1207.14 MHz. These frequencies correspond to Galileo E1, E2, E6 and E5a, respectively. Solutions to the interoperability of COMPASS with other GNSS systems and non-interfering compatibility with those systems remain unpublished.

OEMV Engines
NovAtel's OEMV family of field upgradeable positioning engines incorporates GPS+GLONASS positioning and AdVance RTK for near-instantaneous convergence.

DL-V3
NovAtel's DL-V3 integrates the OEMV-3 positioning engine with Ethernet, USB, Bluetooth and Compact Flash data logging capability. Omnistar™ HP satellite corrections also available.

SPAN
NovAtel's SPAN Technology provides tightly coupled GPS and inertial capability for improved navigation, accurate attitude determination and bridging of satellite outages. IMUs from Honeywell, Northrop Grumman and IMAR supported.

Antennas
NovAtel's pinwheel antennas provide pinpoint accuracy and ideal radiation patterns. Our special purpose antennas are ideal for high-performance land and air vehicle applications.

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